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EFFECT OF ORGANIC AND CHEMICAL FERTILIZER ON GROWTH, YIELD AND FRUIT QUALITY OF PAPAW

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ABSTRACT

The effect of recommended and double dose of NPK fertilizer was tested with and without broiler litter (BL-5kg/tree) or cattle manure (CM-7.5 kg/tree) on growth, yield and fruit quality of papaw variety HORDI – 1 in a Reddish Brown Latosolic soil (*Rhodudults*). Boron was also tested with NPK for bumpy fruit disorder. Number of leaves, stem circumference and canopy diameter of the tree at flowering stage were increased with double dose of NPK fertilizer over the recommended dose. Combined use of CM or BL with recommended dose of NPK showed similar increase of these parameters as double dose of NPK. Boron did not show any effect on these parameters. Fruit yield was increased by 35% with double dose of NPK fertilizer and by 40% with combined use of CM with recommended dose of NPK fertilizer as opposed to recommended dose alone. Use of double dose of NPK fertilizer with CM did not show further yield increase. Combination of CM was superior to BL on yield performance. Yield increase was governed by increase in number of fruits per tree and fruit weight. Boron did not influence yield. Consistent yields were obtained when NPK fertilizer was combined with either CM or BL. Formation of smaller and bumpy fruits was reduced with CM but increased with BL. Application of boron reduced bumpy fruit formation. Total flesh weight and ratio of total soluble solids to total acidity of the fruit pulp increased with combined application of CM and NPK fertilizer. Combined use of CM at 7.5 kg / tree at six month intervals with recommended dose of NPK fertilizer is appropriate for papaw grown in these soils and climatic conditions. In the absence of CM, double recommended dose of NPK fertilizer is required.

KEYWORDS: Broiler Litter, Cattle Manure, Combination, NPK Fertilizer, Papaw.

INTRODUCTION

The cultivated extent of papaw (*Carica papaya L.*) in Sri Lanka has increased rapidly during the last five years due to increased income generated through local and export demand. The current extent is about 4000ha and majority is market-oriented cultivations. Most papaw growers do not follow recommended nutrient management practices and use liberal amounts of chemical fertilizers without further yield increase and fruit quality improvement, which increases cost of cultivation (Jayasundara, 1999). The nutrition of papaw differs from other fruit crops because of its quick growth, continuous fruiting habit, heavy fruit yield and its semi-perennial nature (Awada and Long, 1980). Das and Sahu (1981) have shown that significantly higher and sustainable fruit yields with improved quality of papaw could be achieved with combined use of organic and chemical fertilizer. Incidence of bumpy fruit formation has been observed during the latter part of the cropping cycle, especially in the dry zone region of Sri Lanka where soil pH is over 7. Bumpy fruits have low sugar content and low marketability and are supposed

to be induced by boron deficiency (Kundu and Mitra, 1982). Therefore, due attention should be paid to nutrient management practices to ensure higher and sustainable production in order to meet the demand. The main objective of this study was to investigate the response to the combined use of either cattle manure (CM) or broiler litter (BL) with recommended or double dose of NPK fertilizer on growth, yield and fruit quality in order to suggest a suitable nutrient management technique.

MATERIALS AND METHODS

A field experiment was carried out to investigate the influence of recommended and double dose of NPK fertilizer with and without BL or CM on growth, yield and fruit quality. An additional treatment was included with combined application of recommended dose of NPK fertilizer and boron (B) in order to study the incidence of bumpy fruit disorder. This study was conducted for two years on a Reddish Brown Latosolic soil at the Horticultural Crop Research and Development Institute (HORDI) in the mid country wet zone (MCWZ) of Sri Lanka. The treatments were arranged in a Randomized Complete Block Design (RCBD) with five replicates. The current fertilizer recommendation (N =100 as urea, P_2O_5= 100 as triple super phosphate and K_2O = 250 as muriate of potash, as g/tree/year in four equal splits) was used as the control treatment. Organic manures were applied before planting and repeated at every 6 - month intervals. Four plants were used for each treatment in each replicate. Soil samples at 20cm depth were collected before fertilizer application and the composite sample was analyzed for site characterization. The BL and CM used for this experiment were also analyzed for major nutrient contents. The planting holes of size $45cm^3$ were prepared at a spacing of $3m^2$. BL and CM were applied at the rate of 5 kg and 7.5 kg/hole respectively for relevant treatments one week before planting and mixed with soil. Chemical fertilizer was applied into planting holes three days prior to planting the seedlings and repeated at three - month intervals. Boron was applied to soil as borax (5g/plant) and was repeated with every chemical fertilizer application. Three-month old potted papaw seedlings (cultivar, HORDI–1) were planted and thinned to one seedling per hole. Supplementary irrigation was practiced whenever necessary. Tree height, stem girth at 30cm above the ground level, number of leaves/tree and canopy diameter at flowering stage were recorded. Cumulative fruit yields were calculated every three months for one year to determine the effect of treatments on yield consistency. Number of fruits/tree, average fruit weight, percentage of bumpy fruits/tree and percentage of small fruits (less than 250g) /tree were also recorded. Fruit quality parameters such as percent pulp yield, total soluble solids (TSS) and total acidity (TA) of fruit pulp at same ripening stage were determined. The ratio of TSS:TA which is mainly responsible for pulp sweetness was calculated.

RESULTS AND DISCUSSION

Important chemical characteristics of soil at the experiment site and nutrient contents of BL and CM used in the study are given in Table 1.

Table 1. Chemical characteristics of soil and total nutrient contents in BL and CM.

Soil			*Organic manure*	
Property	*Value*		*BL*	*CM*
pH (1:1)	5.2		8.1	6.9
Total N (%)	0.32		2.77	1.48
Olsen P (mg kg^{-1})	2.10	Total P (%)	1.23	0.92
Exch. K (mg kg^{-1})	13.81	Total K (%)	2.16	1.10
Organic matter (%)	1.83			

The soil at the experiment site was acidic with very low level of available P, marginal level of exchangeable K and low level of organic matter and total N content. The pH of BL was basic whereas CM was neutral. The N, P and K contents of CM were lower than those of BL (Table 1).

Crop performance

Growth

Effect of different treatments on tree height, number of green leaves per tree, stem girth (30cm above ground level) and canopy diameter at the beginning of flowering stage are given in Table 2.

Table 2. Effect of different treatments on growth parameters at the beginning of flowering stage.

Treatment	*Tree height(cm)*	*No. of green leaves / tree*	*Stem girth (cm)*	*Canopy diameter (cm)*
NPK	96.2	17 b	13.3 b	118 b
2 NPK	98.0	21 a	18.1 a	134 a
NPK + CM	106.5	22 a	17.9 a	126 ab
NPK + BL	112.0	20 a	16.2 ab	127 ab
2 NPK + CM	108.2	21 a	18.9 a	137 a
2 NPK + BL	106.6	21 a	18.5 a	136 a
NPK + Boron	94.6	18 b	13.6 b	110 b
CV (%)	19.1	23.6	19.3	32.6

Means followed by the same letters are not significantly different at p=0.05.
NPK = Recommended NPK levels 2NPK = Double dose of recommended NPK levels

Tree height was not affected by different treatments tested. The highest number of green leaves at the first flowering stage was recorded with double dose of NPK fertilizer and also with combined use of BL or CM with NPK. Stem girth and canopy diameter of the tree increased significantly with 2 NPK and also with NPK + BL and NPK + CM. The lowest values of these

parameters were recorded at recommended dose of NPK level except plant height. Addition of B did not show any improvements to these parameters (Table 2).

Yield

Yield parameters such as total fruit yield, number of fruits/tree and mean fruit weight were evaluated for a period of one year and the mean values are presented in Table 3.

Table 3. Yield parameters recorded for one - year period.

Treatment	*Total fruit yield (kg / tree)*	*Total number of fruits / tree*	*Mean fruit weight (g)*
NPK	28.3 b	33 b	857 ab
2 NPK	38.3 a	42 a	909 a
NPK + CM	39.6 a	46 a	861 ab
NPK + BL	30.4 b	38 ab	800 b
2 NPK + CM	40.5 a	45 a	900 a
2 NPK + BL	32.1 b	40 ab	802 b
NPK + Boron	27.3 b	31 b	880 ab
CV (%)	23.7	13.0	28.1

Means followed by the same letters are not significantly different at p=0.05.

The total fruit yield was significantly increased by 2 NPK over single NPK dose. This increment was about 35%. However, 40% yield increase was recorded by NPK + CM over single NPK dose. On the other hand, comparable fruit yields were obtained when CM was combined with either NPK or 2 NPK. Combination of CM with NPK was superior to combination of BL with NPK. Addition of B had no effect on yield. Total number of fruits harvested was significantly increased by 2 NPK over NPK dose. There was no significant difference observed in number of fruits per tree when either CM or BL was combined with NPK. The mean fruit weight was significantly decreased by BL combined with NPK, compared to CM combined with NPK. However, mean fruit weight was not increased by combination of CM with NPK compared to only NPK. Use of B did not show any effect on mean fruit weight.

The treatment effect on formation of smaller fruits (less than 250g) and bumpy fruits, which are unmarketable, are presented as percentage of total number fruits/tree and total fruit weight/tree in Table 4.

Table 4. Treatment effects on unmarketable fruit yields.

Treatment	*No. of smaller fruits(%)*	*% weight of smaller fruits*	*No. of bumpy fruits(%)*	*% weight of bumpy fruits*
NPK	17.6 a	5.1 a	14.3 a	13.3 b
2 NPK	12.7 b	3.5 b	12.1 b	11.9 b
NPK + CM	8.3 c	2.4 b	6.5 c	7.2 c
NPK + BL	18.2 a	5.7 a	16.3 a	18.1 a
2NPK + CM	6.9 c	1.9 c	7.3 c	8.6 c
2NPK + BL	16.5 a	5.1 a	18.0 a	21.3 a
NPK + Boron	10.8 b	3.1 b	4.2 c	5.1 c
CV (%)	25.3	32.5	28.9	25.6

Means followed by the same letters are not significantly different at p=0.05.

Formation of small fruits (less than 250g) and bumpy fruits were significantly reduced with application of 2 NPK compared to the recommended dose. This was further reduced with combined use of CM and NPK fertilizer. However, this incidence was further enhanced when BL was combined with NPK fertilizer (Table 4). Satiskumar and Sharma (1974), Plessis (1975) and Marler (1998) reported that formation of smaller fruits and bumpy fruits were due to sudden pH increase in the soil solution, which leads to temporary unavailability of some major nutrients and micronutrients such as B. Application of BL, which has a basic reaction, may create this situation in the soil solution temporarily. Fruits formed under this temporary condition have less possibility to grow well. As a result, they are small and abnormally developed and finally develop into bumpy fruits.

Yield consistency

The cumulative fruit yield collected during 12 months was divided into four consecutive 3-month periods to study the treatment effect on yield consistency for duration of one year. The treatment effect on cumulative fruit yields collected at the end of each 3- month interval is illustrated in Figure 1 for one- year period. It clearly shows that combined use of either CM or BL with NPK or 2 NPK provided consistent fruit yields throughout the study period compared to only NPK application. Awada and Long (1978) reported that higher and consistent fruit yields are achievable when organic manure was combined with inorganic NPK fertilizer. This may be due to slow and consistent release of plant nutrients from applied organic manure and thereby ensuring continuous supply of nutrients for better plant growth. Results generated from present study support these findings.

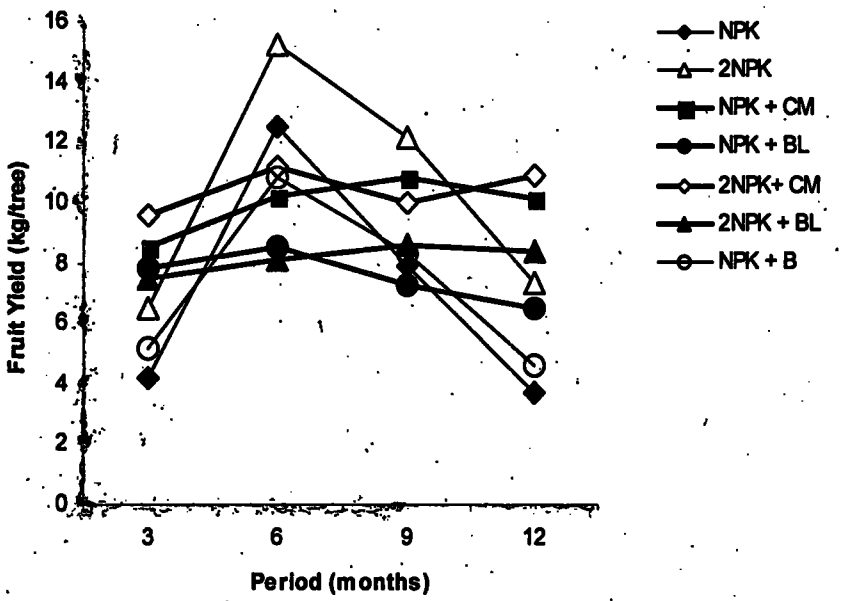

Figure 1. Cumulative fruit yields recorded at the end of each 3- month period for one year.

Fruit quality

Effect of treatments on fruit quality parameters such as percent pulp yield, total soluble solids (TSS) and total acidity (TA) of the fruit pulp and ratio of TSS: TA is presented in Table 5.

Table 5. Effect of different treatments on fruit quality.

Treatment	*% pulp yield*	*TSS (mg/100g)*	*TA (mg/100g)*	*TSS: TA*
NPK	68.2 b	11.6 b	0.86 a	13.49 b
2 NPK	72.5 ab	10.9 b	0.83 a	13.13 b
NPK + CM	80.1 a	14.5 a	0.75 b	19.33 a
NPK + BL	82.0 a	13.1 a	0.78 ab	16.79 a
2 NPK + CM	83.6 a	15.3 a	0.77 b	19.87 a
2 NPK + BL	82.5 a	13.1 a	0.82 a	15.98 a
NPK + B	72.6 ab	10.8 b	0.79 ab	13.67 b
CV (%)	27.6	31.5	28.2	34.1

Means followed by the same letters are not significantly different at p=0.05.

Percentage fruit pulp increased significantly with application of double dose of NPK over recommended dose. The highest percentage of fruit pulp and TSS of the fruit pulp were recorded with combined use of either CM or BL with recommended or double dose of NPK fertilizer. In contrast, total acidity of the fruit pulp decreased with combination of CM with NPK fertilizer. As a result, ratio of TSS:TA increased with application of CM or BL (Table 5). Sulladmath *et al.* (1981) reported that combined application of CM with chemical fertilizer reduced the thickness of the skin and the weight

of seeds in most fruits and as a result, percent pulp yield increased. Alexandrescu *et al.* (1978) also showed that use of cattle manure increased fruit yield, improved sugar content and reduced acidity of fruit pulp.

Profitability

The fertilizer cost and income gained from each treatment for one hectare of cultivation for two - year period is illustrated in Figure 2.

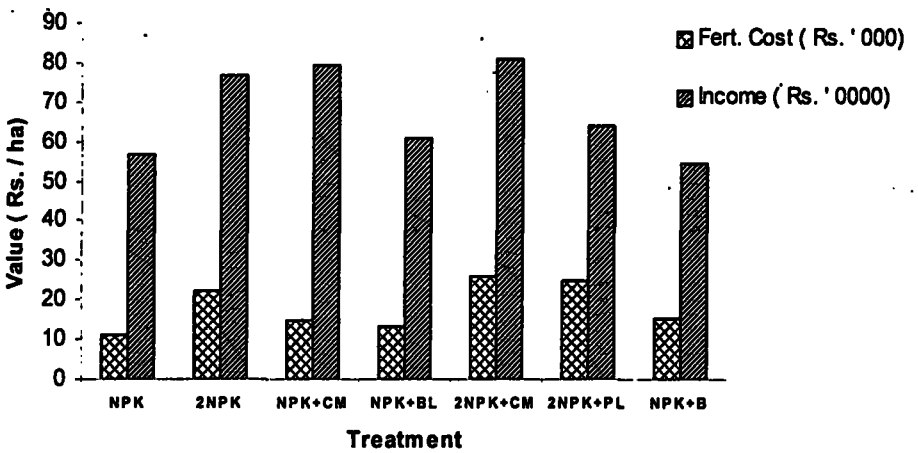

Figure 2. Fertilizer cost and income gained from each treatment.

Income generated from treatments 2 NPK, NPK + CM and 2NPK + CM were comparable and significantly higher than those of other treatments tested. However, treatment NPK + CM had the lowest fertilizer cost and therefore, had the highest profit which was about 40% over the recommended NPK. Profit gained from 2 NPK was about 35% over the recommended NPK.

CONCLUSIONS

The study reveals that currently recommended NPK dose is insufficient to achieve high yields of papaw under these soil conditions. Further yield improvement of about 35% is possible by doubling the currently recommended dose of NPK fertilizer. However, further research is needed to find out whether all three nutrient levels need to be doubled. By using combination of CM with only recommended dose of NPK fertilizer, at the rate of 7.5 kg/tree at 6-month intervals, a similar yield increase could be achieved. Combination of CM with double dose of NPK was not beneficial. Combination of CM was better than BL with NPK under these soil conditions. However, a consistent fruit yield is achievable when recommended dose of NPK fertilizer is combined with either CM or BL. Formation of smaller fruits

and bumpy fruits could be reduced by combination of CM with NPK. Combination of BL with NPK fertilizer is not recommended due to formation of higher percentage of bumpy and smaller fruits under these soil conditions. Addition of B was beneficial to reduce bumpy fruit disorder. Higher fruit yield with low fertilizer input, higher percent of fruit pulp and increased sweetness are possible by combining CM with recommended NPK fertilizer. In the absence of CM, double the recommended dose of NPK fertilizer is required.

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